METHOD FOR FORMING AN OPTO-ELECTRONIC DEVICE

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

This present invention relates to a method for forming an opto-electronic device, and more particularly to a method for forming an opto-electronic device through a solid state growth process at low temperature.

2. DESCRIPTION OF THE PRIOR ART

In recent years, the opto-electronic devices, e.g. Light-Emitting Diodes (LED), solar cells and light sensors, have become more and more popular. During forming an LED, the electrodes of the LED are formed on a substrate consisted of compound semiconductor, e.g. GaAs, GaN or InP. For forming well ohmic contact between the electrodes and the substrate, the LED has to be treated at the temperature being higher than 400 degrees centigrade, i.e. 400 ℃. If an improper material with a melting point being lower than 400 degrees centigrade is used to be on of the elements of the LED device, the improper material may be melted or be transformed lattices of itself in a high temperature process being higher than 400℃, e. g. Rapid Thermal Annealing Process, RTP. The material of the compound semiconductor and the active layer may be destroyed to reduce the quality and the illuminant efficiency of the opto-electronic device, i.e. the LED. The yield for producing the opto-electronic devices is also reduced because the structure of the elements is destroyed.

Futhermore, the illuminant efficiency of an LED device with an opaque substrate has to be increased. An opto-electronic device, e.g. an LED device, with a transparent substrate is constructed to improve the disadvantage of an opto-

electronic device with an opaque substrate that absorbs light and decreases the illuminating efficiency of the opto-electronic device. However, for forming ohmic contact between electrodes and the substrate, almost all elements of the opto-electronic device have to suffer the temperature being higher than 400 degrees centigrade. The heat produced in the process at the temperature being higher than 400 degrees centigrade limits the material of elements. The materials of elements of the opto-electronic device must be selected from the materials with the melting point or the glass transition temperature that is higher than 400 degrees centigrade.

Hence, it is an important objective for developing a method for forming an opto-electronic device, e.g. an LED device, to reduce the disadvantage of the prior art, increase the selectivity of the materials of the elements and increase the yield for producing the opto-electronic device.

SUMMARY OF THE INVENTION

In accordance with the present invention, a method for forming an opto-electronic device at low temperature is provided. According to the above-mentioned method, an objective of the present invention is to provide an opto-electronic device formed through a solid state growth process at the low temperature to increase the selectivity of the materials of the elements and the yield for producing opto-electronic devices.

It is another object of the present invention to provide a method for forming an opto-electronic device through a solid state growth process at the low temperature to form a transparent substrate within the opto-electronic device to increase the illuminant efficiency.

It is further another object of the present invention to provide a method for

forming an opto-electronic device through a solid state growth process at the low temperature to prevent the elements, e.g. an active layer or an adhesive layer, of the opto-electronic device from destroyed by the high temperature. The method of the present invention increases the operating efficiency of the opto-electronic device.

In accordance with the above-mentioned objects, the invention provides a method for forming an opto-electronic device through a low temperature process. An opto-electronic layer formed on a substrate of the opto-electronic device. An electric conductive element is formed on the opto-electronic layer through a solid state growth process at the low temperature.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing aspects and many of the attendant advantages of this invention will become more readily appreciated as the same becomes better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

Fig. 1A to FIG. 1E are profile diagrams for forming an LED device according to this present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Some sample embodiments of the invention will now be described in greater detail. Nevertheless, it should be recognized that the present invention can be practiced in a wide range of other embodiments besides those explicitly described, and the scope of the present invention is expressly not limited except as specified in

the accompanying claims.

Then, the components of the devices in this application are not shown to scale. Some dimensions are exaggerated to the related components to provide a more clear description and comprehension of the present invention.

The present invention provides a method for forming an opto-electronic device at the low temperature. The electric conductive elements of the opto-electronic device are formed through a solid state growth process at the low temperature. The opto-electronic device is formed at the low temperature, so that the material of the elements of opto-electronic device of the present invention can be selected from the material with lower melting point or lower glass transition temperature. It is much easier to select the material of the element of the present opto-electronic device. For example, the material of an opaque substrate or a transparent substrate can be selected from both the material with higher melting point or the material with lower melting point. The material of the electric conductive elements can be selected from both the material with higher melting point or the material with lower melting point. Furthermore, the structure of every element of the opto-electronic device of the present invention is more stable because the processes processing at the lower temperature cannot destroy the structure of every element. Thus the opto-electronic devices of the present invention includes higher operating quality, higher operating efficiency and more practical applications for different kinds of devices.

The profile diagrams of the embodiment of the present invention are shown in FIG. 1A-1E. The substrate of the opto-electronic device of the present invention may be an opaque substrate, e.g. a substrate with GaAs, or a transparent substrate, even if the substrate of the embodiment of the present invention is a transparent substrate. As shown in FIG. 1A, an opto-electronic layer is formed, e.g. deposited, on a substrate 210. The opto-electronic layer includes a first semiconductor layer 220,

an active layer 230 and a second semiconductor layer 240. As shown in FIG. 1B, an adhesive layer 250 is formed on the second semiconductor layer 240 and a substrate 260, i.e. a transparent substrate, is formed on the adhesive layer 250 subsequently. The adhesive layer 250 adheres the substrate 260 on the second semiconductor layer 240.

As shown in FIG. C, the substrate 210 is removed and then the opto-electronic device is turned over. The substrate 210 is removed by a lapping process, an etching process, or both of the lapping process and the etching process. There may be an etching stop layer formed between the opto-electronic layer and the substrate 210 for stopping etching.

A structure for emitting light being not shown in FIG. 1C is defined within the opto-electronic layer according to a pattern of a photoresist layer formed on the opto-electronic layer, wherein the photoresist layer is not shown in FIG. 1C either. To form the structure for emitting light, portions of the first semiconductor layer 220, portions of the active layer 230 and portions of the second layer 240 are etched in an etching process, e.g. a dry etching process or a wet etching process, as shown in FIG. 1D.

As shown in FIG. 1E, electric conductive elements, e. g. an electrode 270 and an electrode 280, are formed on the first semiconductor layer 220 and the second semiconductor layer 240 respectively by an electron beam evaporation process, a sputtering deposition method, thermal evaporation process or another kind of deposition method. Subsequently, the opto-electronic layer and the electrode 270 and 280 are treated through a solid state growth process, i.e. SPR process, to form ohmic contact between the electrode 270 and the first semiconductor layer 220, and between the electrode 280 and the second semiconductor layer 240.

The order for forming the electrodes 270 and 280 and ohmic contact between

the electrodes and the substrate layers 220 and 240 changes for necessity. For example, as shown in FIG. 1C to FIG. 1E, the electrode 270 and the electrode 280 are formed on the first semiconductor layer 220 and the second semiconductor layer 240 before forming ohmic contact through the SPR process. The other order is not shown in FIG. 1A-1E, the electrode 270 can be formed on first semiconductor layer 220 of the structure as shown in FIG. 1C. After the first semiconductor layer 220, the active layer 230 and the second semiconductor layer 240 are etched to be the structure as shown in FIG. 1D, the electrode 280 is formed on the second semiconductor layer 240 as shown in FIG. 1E. The opto-electronic device of the present invention is treated through the SPR process to form ohmic contact between the electrode 270 and the first semiconductor layer 220, and between the electrode 280 and the second semiconductor layer 240. Furthermore, according to the second order for forming the electrodes 270 and 280 and ohmic contact, the opto-electronic device may be treated through the SPR process twice to for ohmic contact. The opto-electronic device may be treated through the first SPR process after the electrode 270 being formed on the first semiconductor layer 270 and before the electrode 280 being formed on the second semiconductor layer 280. The opto-electronic device is treated through the second SPR process to form ohmic contact after the electrode 280 being formed on the second semiconductor layer 280. Of course, the order for forming the electrodes and ohmic contact of the present invention is not limited on the above description.

The temperature for treated the electrode 270 and the electrode 280 is controlled to be lower than 250 degrees centigrade. The temperature for treated the electrode 270 and the electrode 280 may also be controlled to be lower than 200 degrees centigrade or 175 degrees centigrade. The temperature may also be controlled higher than 100 degrees centigrade, 150 degrees centigrade or 175 degrees centigrade. Because the temperature for treated the electrodes 270 and 280 of the opto-electronic device of the present invention is much lower than that of the prior art, the active layer 230 and other elements of the opto-electronic layer of the present invention is not affected by high temperature. So that the operating quality of the

active layer 230 and the whole opto-electronic device of the present invention is better than that of the prior art.

The structure of the opto-electronic device of the embodiment of the present invention is a structure of light emitted device, LED. The structure of the active layer 230 may be a quantum well. The first semiconductor layer 220 is a n-type doped semiconductor layer, and the second semiconductor layer 240 is a p-type doped semiconductor layer of this embodiment. Of course, the first semiconductor layer 220 may be a n-type doped semiconductor layer, and the second semiconductor layer 240 is a n-type doped semiconductor layer of the present invention. Furthermore, the structure of the opto-electronic layer of the present invention is not limited on the structure of the above embodiment.

The electric conductive elements, i.e. the electrode 270 and the electrode 280, are formed by many kinds of the material. The material may be Ni, Pd, Ge, Si, Se, Zn, Be, Mg, Cd, Au, Ag, Pt and the components consisted of Au, Ag and Pt, e.g. AuAg, AgPt, AuPt and AuAgPt, wherein the order for consisting the Au, Ag and Pt can be exchanged. To explain more clearly, the letter 'A' means the material Ni and Pd. The letter 'B' means the material Ge, Si and Se. The letter 'C' means the material Zn, Be, Mg and Cd. The letter 'D' means the material Au, Ag, Pt and the material consisted of Au, Ag, Pt. The materials of the electrodes 270 and 280 are ABD and ACD, wherein the order of ABD can be exchanged, and ACD does, too. The electrode 220 consisted of ABD is selected to be formed on the first semiconductor layer 270 being a n-type doped semiconductor layer. The electrode 240 consisted of ACD is selected to be formed on the second semiconductor layer 280 being a p-type doped semiconductor layer. Of course, the material of the electrodes of the present invention is not limited on the above material.

The material of the substrate 260, i.e. the transparent substrate, may be glass, silicon, epoxy resin, poly methyl methacrylate, acrylonitrile butadiene styrene

copolymer resin, and polymethyl methacrylate, sapphire. The material of the substrate 260 may also be polysulfones, polyethersulfones, polyetherimides, polyimides, polyamide-imide, polyphenylene sulfide and silicon-carbon thermosets. The material of the substrate 260 of this embodiment of the present invention is glass.

The adhesive layer 250 is transparent. The material of the adhesive layer 250 may be epoxy resin, acrylonitrile butadiene styrene copolymer resin and polymethyl methacrylate. The material of the adhesive layer 250 may also be polysulfones, polyethersulfones, polyetherimides, polyimides, polyamide-imide, polyphenylene sulfide and silicon-carbon thermosets. The material of the adhesive layer 250 of this embodiment of the present invention is epoxy resin.

If the adhesive layer 250 of the present invention is a transparent solid at the room temperature, the adhesive layer 250 can replace the transparent substrate 260 formed on the second semiconductor layer 240. So that the step for adhering or forming the substrate 260 on the second semiconductor layer 240 is reduced. The cost of the substrate 260 is reduced, too. The substrate 260 can be the material with lower melting point. The adhesive layer 250 can be also the material with lower melting point. It is more conveniently to choose the material of the substrate 260 and the adhesive layer 250 of the present invention and more conveniently to form the substrate 260 on the opto-electronic layer.

The opto-electronic device in the present invention may be elements of solar cells, a light sensor or other opto-electronic technology devices including electric conductive elements, even though the opto-electronic devices of the described preferred embodiment is a LED device with a transparent substrate.

The present invention forms an opto-electronic layer on a substrate at the lower temperature. The electric conductive elements of the opto-electronic device are

formed through a solid state growth process at the low temperature. The opto-electronic device is formed at the low temperature, so that the material of the elements, e.g. an epoxy substrate, with lower melting point or lower glass transition temperature of opto-electronic device of the present invention can be selected. It is much more conveniently and much easier to select the material of elements of the present opto-electronic device. The material of the electric conductive elements can be selected from both the material with higher melting point or the material with lower melting point. The step for forming the substrate on the opto-electronic layer is also more conveniently. The structure of every element of the opto-electronic device of the present invention is more stable because the processes processing at the lower temperature cannot destroy the structure of every element. Thus the opto-electronic devices of the present invention includes higher operating quality, higher operating efficiency and more practical applications for different kinds of devices. Furthermore, if the substrate of the opto-electronic device is transparent, the present invention also provides an opto-electronic device with higher illuminant efficiency and higher operating efficiency. The present invention further increases the yield for producing opto-electronic devices.

Although specific embodiments have been illustrated and described, it will be obvious to those skilled in the art that various modifications may be made without departing from what is intended, but not to be limited solely by the appended claims.